12

THE HIGHLY REFRACTIVE PROTONEMA OF *MITTENIA PLUMULA* (MITT.) LINDB. (MITTENIACEAE)

By Ilma G. Stone MSc

[Read 8 December 1960]

Abstract

The discovery of a highly refractive protonema belonging to the moss *Mittenia plumula* is reported. The peculiar protonema which produces lens-like cells is described, and a comparison of the moss made with *Schistostega pennata* (Hedw.) Hook. and Tayl., the only other moss known to possess a similar protonema.

Introduction

A green filamentous growth with a luminous appearanee was found in the Sherbrooke Forest in the Dandenong Ranges near Melbourne. It was growing on the floor of a dimly lit cavity under a fallen tree fern.

The material was thought at first to be the protonema of the moss *Schistostega pennata* whieh is not recorded for Australia.

The protonema was found later in a number of similar situations in the same loeality, in many eases with attaehed gametophores of a moss identified as *Mittenia plumula.*

A detailed examination of the gametophore and the sporophyte revealed some differences from previous descriptions (Sainsbury 1955) and these, with details of the development of the peristome, will be the subject of a second paper on *Mittenia plumula.*

The Protonema

As in *Schistostega pennata* (Goebel 1905), the protonema of *Mittenia plumula* has two phases, the highly refraetive stage with lens-like eells (Pl. XX, fig. 1-2) whieh reaches its highest development when the moss is growing where light is dim and unilateral, and the normal moss type of protonema with cylindrical cells (Pl. XX, fig. 2) whieh is found in the same situations as the previous stage, but is better developed where the light intensity is greater. Aerial braneh es of both phases and the base of an attaehed gametophore are shown in Fig. 1. Between the two extreme phases intermediate stages are found (Fig. 2-3) and one phase frequently passes over to the other. Either phase may also produee colourless finely braneh ing rhizoids (Fig. 4).

A stoloniferous type of filament which is sometimes very robust and thick-walled extends over the substratum for a eonsiderable distanee and gives rise to the aerial braneh es, rhizoidal branches and gametophores. Pl. XXI shows a sterile shoot and Pl. XXII a very young shoot attaehed to the protonema.

Although there is considerable variation, the system of braneh ing of aerial filaments is frequently the same in both phases and, when growth is luxuriant, the branches generally arise practically opposite to eaeh other just behind a cross wall. The tips of the cells in the eylindrieal type are rounded.

In the specialized highly refraetive stage the braneh es are eomposed of lentieular cells spread out in a plane at right angles to the light and sometimes appearing like

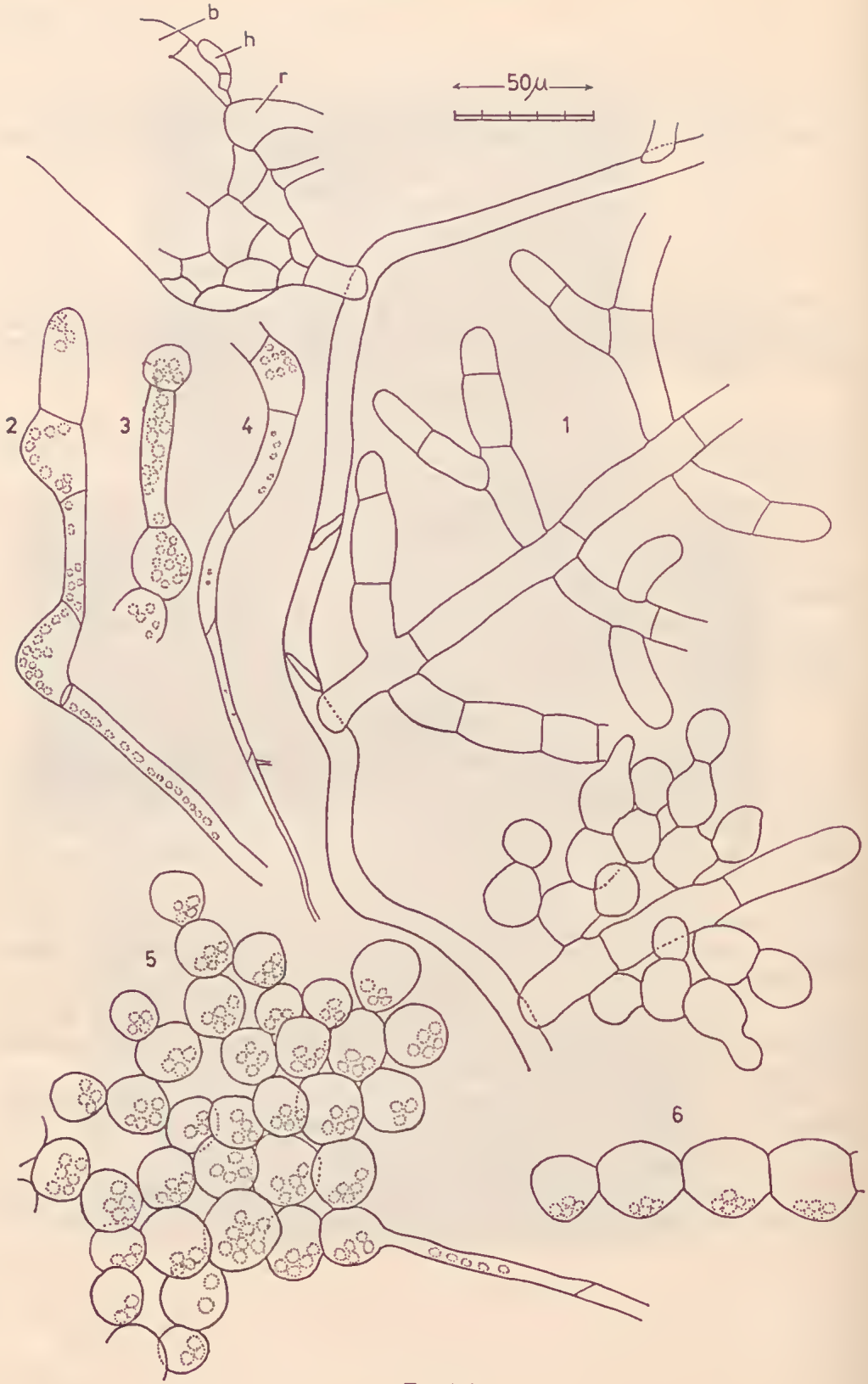

FIG. 1-6.

plates of tissue as shown in Fig. 5 and Pl. XX, fig. 1. Fig. 6 shows the shape of the cells and the position of the chloroplasts which are massed near the more highly convex underside of the cell. Light rays falling on the lens-shaped cells are concentrated on the chloroplasts. As with *Schistostega* the apparent luminosity is produced by the light rays, which are not absorbed by the chloroplasts, being reflected back and when this reflected light is of sufficient intensity the protonema exhibits a striking green lustre. Pl. XX, fig. 3 is a photograph of the protonema on a piece of earth, at which a light was directed. The bright areas are regions of the lenticular protonema which received the incident light from a suitable direction.

The spores of *Mittenia plumula* germinated on mineral solution, sending out a germ tube (Fig. 7-8) in a few days, but further development was slow and Fig. 9-12 show stages reached after several weeks on mineral solution in dim light. Many spores developed two germ tubes.

Fig. 19 shows aerial branches with lenticular cells which were grown on moist clay in a room facing south. The terminal cell of one branch has grown out into a narrow filament. This was characteristic of the protonema. Fig. 13-15 show early stages in the development of the lenticular protonema. Each new lens-shaped cell arises as a papilla into which a few chloroplasts pass (Fig. 15). Nuclear details were not observed.

Stout protonemal filaments may grow out from the apex of injured shoots, and also develop from the surface of the stem usually above the insertion of a leaf. Dark green gemmae of two to four cells in a row were formed by some of these filaments.

Fig. 16 shows a gemma attached to the tip of a specialized cylindrical cell, Fig. 17 a germinating gemma and Fig. 18 a gemma which had brown walls and dense green contents detached from the parent cell.

Occasionally brown gemmae were found on rhizoids (Fig. 20). Aerial protonema of both types may develop from the rhizoids of the gametophore.

Discussion

Schistostega pennata is the only member of the order Schistostegales and the refractive protonema is stressed as a character of the order. *Mittenia plumula,* which is the only member of the family Mitteniaccae in the order Eubryales, now also has been found to have a refractive protonema.

The discovery of a second moss with a highly refractive protonema leads to speculation as to whether it is a similar response on the part of two unrelated species, that is, that the lenticular condition arose independently in *Schistostega* and *Mittenia,* or whether there is actually a close relationship between the two mosses.

It is interesting and possibly significant that early descriptions of the gametophore of *Mittenia plumula* (formerly *Mniopsis plumula* Mitt.) (Hooker 1860, Muller 1901) are accompanied by a comparison with the gametophore of *Schistostega* to which it seemed most closely related morphologically. In each case there is a vertical insertion and distichous arrangement of the decurrent leaves on mature sterile shoots, although the leaves are primarily transversely inserted and radially arranged.

In *Schistostega* the leaves have no costa and the cells are very large and elongated. In *Mittenia,* although the lower leaves often have elongated cells and no costa, the cells are never as large as those of *Schistostega,* and the leaves higher on the stem have isodiametric cells and a costa which vanishes above midleaf.

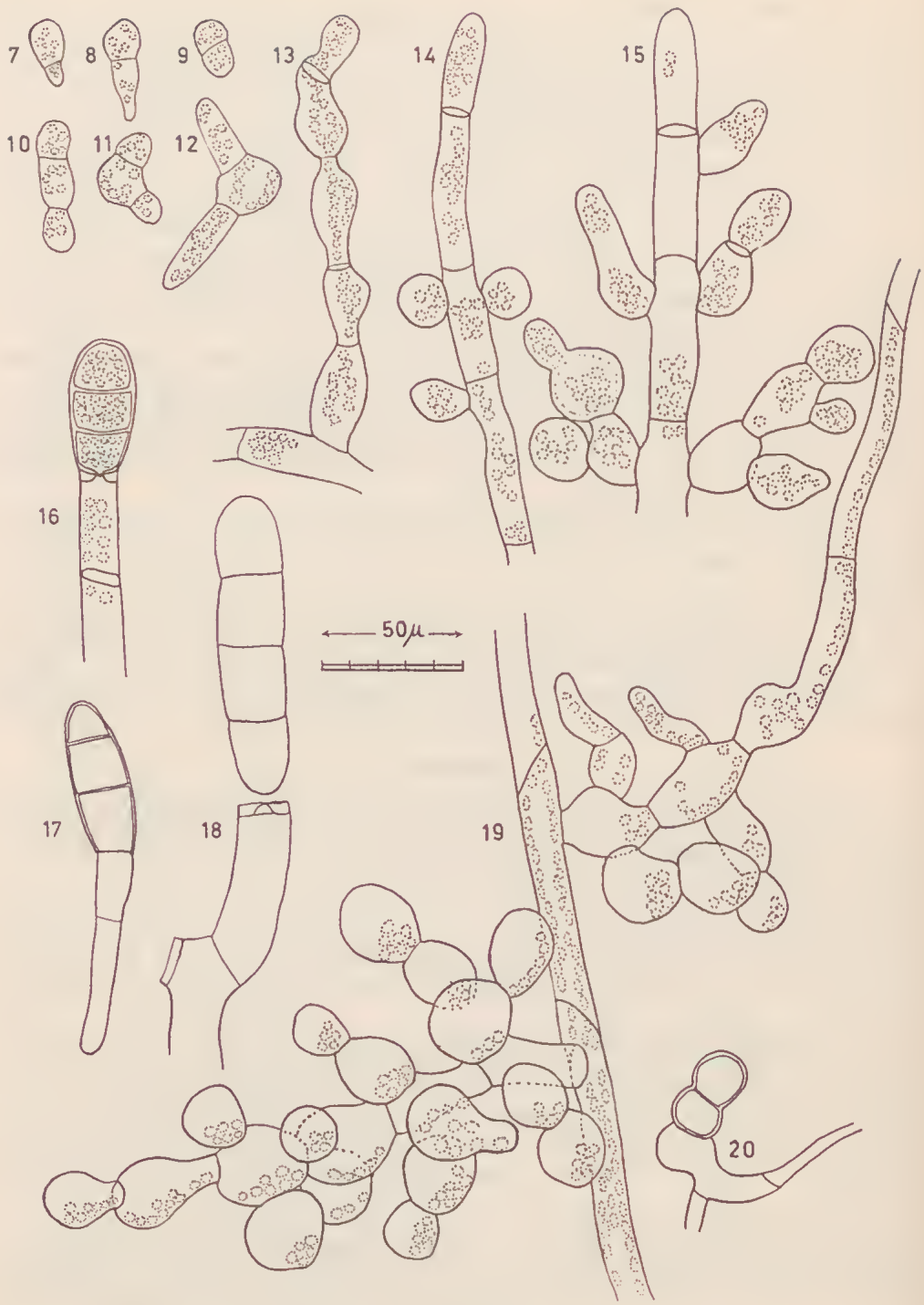

FIG. 7-20.

These differences would not necessarily debar relationship between the two mosses, as such differences are present in the species of certain other genera, e.g. *Fissidens* Hedw.

The fertile shoots in both mosses have a radial arrangement of leaves with transverse to oblique insertion. Some of the male shoots in *Mittenia* resemble those of *Schistostega* in having few or no leaves on the stem with a tuft at the top.

Goebel (1905) reports that hairs are present in the axils of leaves on female shoots of *Schistostega* and, although *Mittenia* was reported in the Latin description (Hooker 1860) as having no paraphyses, club-shaped hairs are present particularly in the axils of the upper leaves on fertile shoots. Brotherus in Engler and Prantl (1924) describes *Schistostega* with no paraphyses and *Mittenia* with paraphyses assosciated with antheridia and archegonia, but these are not shown in the illustrations.

Mittenia forms gemmae on protonemal filaments and these have also been mentioned (Goebel 1905) for *Schistostega*.

There is a difference in the mode of social growth in the two mosses. In *Schistostega* new shoots form from short protonemal filaments arising from the base of the old shoot (Goebel 1905). In *Mittenia* a bud associated with hairs is formed at the base of a gametophore giving rise to a new shoot and the early stage of one of these buds is seen in Fig. 1.

The sporophyte in both mosses is terminal but the complicated capsule of *Mittenia* shows no resemblance to the capsule of *Schistostega* which is extremely simple and has no peristome. Plants which have undergone reduction present problems in assessing affinities, and presence or absence of a peristome does not necessarily indicate a lack of relationship, as witnessed by the genus *Orthotrichum* Hedw., in which one species has no peristome while other species have a double or a single peristome.

Acknowledgements

The protonema was first found in April 1960 by Mrs J. S .Turner. Thanks are due to Professor Turner for introducing the author to the subject, to Dr Ethel McLennan for advice and encouragement, to Mr J. H. Willis for confirming the identification, and to Mr E. J. Matthaei for the photographs. The author is in receipt of a research grant from the University of Melbourne, and the work was carried out in the Botany Department.

References

Engler, A., and Prantl, K., 1924. *Die Naturlichen Pflanzenfamilien.* 2 Aufl. Bd. 10. Verlag von Engelmann: Leipzig.

Goebel, K., 1905. *Organography of Plants.* Vol. 2. 2nd Eng. Ed. Trans. I. B. Balfour. Oxford.

Hooker, J., 1860. *Fl. Tasm.* 11, 187, t 173 (*Mniopsis* Mitt.). Lovell Reeve, London.

Muller, C., 1901. *Genera Muscorum Frondosorum.* Eduard Kummer, Leipzig.

Sainsbury, G. O. K., 1955. *A Handbook of the New Zealand Mosses.* Royal Society of N.Z. Bulletin No. 5. R.S.N.Z. Wellington.

Explanation of Plates

Plate XX

Protonema of *Mittenia plumula*

Fig. 1—Highly refractive phase of the protonema x *c.* 230.
Fig. 2—Refractive phase and a small portion of protonema showing cylindrical cells x *c.* 230.
Fig. 3—Highly refractive protonema on a piece of earth at which a light was directed x *c.* 15.

PLATE XXI

Sterile gametophore of *Mittenia plumula* attached to protonema. Many of the rhizoids of the moss plant have been removed. A stout one remains at the right of the plant. x *c.* 50.

PLATE XXII

Part of an extensive protonema with a young gametophore attached. Note stoloniferous filament giving off branches. x *c.* 70.

Legend to Figures 1-20

FIG. 1–6—(1) Stoloniferous filament with aerial branches of both phases of the protonema and the base of a gametophore (h hair, b bud, r rhizoid). (2, 3) Intermediate stages between the two phases of the protonema. (4) Gradual transition of green protonemal cells to fine colourless rhizoidal cells. (5) Maximum development of the highly refractive protonema. All the cells are lens-shaped. (6) A few lens-shaped protonemal cells showing the aggregation of chloroplasts in the underside of the cells.

FIG. 7–20—(7, 8) Germinating spores on mineral solution a few days. (9-12) Germinating spores on mineral solution for several weeks. Spores with one or two germ tubes. (13-15) Early stages in the development of the lenticular protonema. Fig. 15 shows stages in the formation of the lens-shaped cells. (16) Gemma at the tip of a filament which grew out from the surface of the stem of a gametophore. The cylindrical cell which bears the gemma is a specialized cell. (17) Germinating gemma. (18) Gemma detached from its parent cell. (19) Protonema grown on moist clay. The terminal cell of one branch has grown out into a filament, a characteristic feature of the protonema. (20) Thick-walled gemma on a rhizoid.